JEE Journal of Ecological Engineering
Volume 19, Issue 1, January 2018, pages 33–41
https://doi.org/10.12911/22998993/79405

Received: 2017.09.06
Accepted: 2017.10.28
Published: 2018.01.01

Assessment Strategies for Municipal Selective Waste Collection – Regional Waste Management

Agnieszka Boas Berg[1], Maja Radziemska[2], Dana Adamcová[3], Jan Zloch[3], Magdalena Daria Vaverková[3*]

[1] Shada BV, Kanaal Noord 350, NL-7323 Am Apeldoorn, Holland

[2] Warsaw University of Life Sciences – SGGW, Faculty of Civil and Environmental Engineering, Department of Environmental Improvement, Nowoursynowska 159, 02-776 Warsaw, Poland

[3] Mendel University in Brno, Faculty of AgriSciences, Department of Applied and Landscape Ecology, Zemědělská 1, 613 00 Brno, Czech Republic

* Corresponding author's e-mail: magda.vaverkova@uake.cz

ABSTRACT

Waste disposal in landfill sites causes a potential hazard for the human health, as they release substantial amounts of gas, odours and pollutants to the environment. There have been vast reductions in the volume of waste being landfilled in many European countries and a reduction in the number of illegal landfills. The European Parliament's laws obliged the Member States to amend the national waste law; the main objectives of the implemented directives are to create the conditions for the prevention of excessive waste. Directive 2008/98/EC establishes, as a goal for 2020, that waste reuse and recycling reach 50% of the total waste produced. Poland, having joined the European Union, committed itself to implementing many changes related to waste management. The amendment of the law on the maintenance of cleanliness and order in the municipalities imposed new obligations regarding the waste management (WM) on the local government and residents. By adopting a municipal waste management system, the selected municipality made all its residents responsible for their waste. However, the fact of introducing changes does not solve the waste problem. The implementation of EU directives and the development of strategic documents such as the National Waste Management Plan (NWMP) have made a clear change in the WM approach. One of the changes was the establishment of selective collection of municipal selective waste (MSW), with the issue of collecting the waste by the residents being a priority. This work describes the legal context of selective collection of MSW as one of the most effective means of reducing the amount of waste being landfilled.

Keywords: solid waste, waste management legislation, waste hierarchy, regional waste management

INTRODUCTION

Waste is a guaranteed component of any urbanized landscape and the management of waste has existed for centuries [Silva et al., 2017]. The WM has, for the most part, provided the end of pipe solutions whereby increasing amounts of discarded materials are buried, dumped out at sea or turned into ash, creating the need for the extraction of further raw materials [Silva et al., 2017]. Moreover, waste disposal in landfill sites causes a potential hazard for the human health as they release substantial amounts of gas, odours and pollutants to the environment [Marchand et al., 2012; Vilavert et al., 2012, Breza-Boruta 2016; Vaverková et al. 2017; Voběrková et al. 2017]. Moreover, landfill sites act as biological reactors in which refuse undergoes physical, chemical and biological transformation [Samadder el al., 2017; Gworek et al., 2015; Koda et al., 2015, Adamcová et al., 2016; Koda et al., 2017; Vaverková et al., 2017; Rong et al., 2017; Wang et al., 2017]. In total, 1.3 billion tons of MSW are produced globally, at an average daily rate of 1.2 kg per capita. By 2025, this amount will increase to 2.3 billion tons per year [Caicedo-Concha et

al., 2016]. In Europe in 2012, 246 million tons of total amounts of MSW were produced (equivalent to 487 kg of MSW per person). The country with the highest production per capita was Switzerland and the country with the lowest one was Romania [Eurostat, 2015].

Eurostat has collected and published the data on MSW since 1995. Six out of 28 member states of the EU: Germany, France, United Kingdom (UK), Italy, Spain and Poland are generating more than 10 million tons of MSW per year. The amount of MSW generated per person varies significantly across the EU, from 759 kg/person in Denmark (highest value) to 254 kg/person in Romania (lowest value). In Austria (565 kg/person), Germany (618 kg/person) and UK (482 kg/person) the amount of MSW per person is above the European average (i.e. 475 kg/person), while in Slovakia (321 kg/person), it is generously below this value. The treatment strategy within the EU has been positively changed, i.e. from 64% of landfilling in 1995 to 28% in 2014 [Pomberger et al., 2017]. There have been vast reductions in the volume of waste being landfilled in many EU countries (Ireland, Czech Republic (CR), Slovenia, Norway, UK, Denmark, Iceland, Austria and Finland) (Brennan et al. 2016). In 2012, 34% of all waste treated across the 28 EU Member States was sent to landfills, 42% was recycled, 4% was incinerated, and 15% was composted or underwent the anaerobic digestion [Eurostat, 2015; Brennan et al., 2016].

The European Parliament's laws obliged the Member States to amend the national waste law; the main objectives of the implemented directives were to create the conditions for the prevention of excessive waste generation. There is no doubt that since 1995 the European MWMS has been developing into an important secondary resources and energy generating sector [Pomberger et al., 2017]. Currently, Directive 2008/98/EC establishes a goal for 2020 that waste reuse and recycling reach 50% of the total waste produced.

Poland, having joined the EU, committed itself to implementing many changes related to WM. The amendment of the law on the maintenance of cleanliness and order in the municipalities imposed new obligations regarding the WM on the local government and residents. The aim of the new policy of local governments is to prevent the generation of MSW as much as possible but also to increase the emphasis on segregating the waste at the place it was produced, i.e. "at its source". A properly functioning system should control the entire waste management process, with sorting of the waste in particular. In order to meet the criteria regarding reducing the amount of waste entering landfills, a number of measures have been taken. The implementation of EU directives and the development of strategic documents such as the National Waste Management Plan (NWMP) have made a clear change in the WM approach. One of the changes was the establishment of selective collection of MSW, with the issue of collecting the waste by the residents being a priority. This work describes the legal context of selective collection of MSW as one of the most effective means of reducing the amount of waste being landfilled.

The impact of EU legislation on waste management in Poland

The complete and correct transposition of the new legislation is essential to guarantee that the law objectives (i.e. protecting human health and the environment, increased resource efficiency within the EU) are achieved [Breza-Boruta 2016; Pomberger et al. 2017]. Poland's joining the EU has led to a change in the WM policy. Poland, as a Member of the EU, has committed itself to implementing all the directives adopted by the European Parliament, including the ones related to the WM. The EU WM policy seeks to create rules that are transparent and easy to apply, particularly in terms of facilitating the use and control of waste production. The most important act that defines the main principles of the European WM is Directive 2008/98/EC of the European Parliament and of the Council of 19th November 2008 on waste. According to the proposal to the Directive of the European Parliament and of the Council amending Directive 1999/31/EC on the landfill of waste, recently issued by the European Commission, the main elements, among others, refer to: increased preparations for the re-use and recycling target for MSW to 65% by 2030 and a gradual decrease of the landfilling of MSW to 10% by 2030. A progressive reduction of landfilling is necessary to prevent the detrimental impacts on the human health and the environment and to ensure that the economically valuable waste materials are gradually and effectively recovered through proper WM, in line with the waste hierarchy [Breza-Boruta, 2016]. As far as the WM in the EU is concerned, Council Directive 99/31 / EC of

26 April 1999 on the landfill of waste along with Directive 94/62 / EC of the European Parliament and of the Council of 20 December 1994 on packaging and packaging waste are equally important. The directives require all Member States (including Poland) to recycle and recover the packaging waste, collect spent batteries and accumulators, as well as meet the landfilling requirements. The EU waste policy aims to reduce the waste production per capita, increase the use of waste as a resource, make recycling attractive to both the private and public sector, as well as eliminate the need of its disposal [Vučijak et al., 2016]. When Poland joined the EU in 2004, the WM law was regulated by the Act on Waste of 27th April 2001, which did not contain all the guidelines presented in the EU directives. Consequently, the law was systematically amended and more regulations were implemented. However, these regulations did not meet the goals set by the directives. As a result, some households still have not signed a contract with the waste collecting company. In order to unify the WM legal issues and improve the statistics on landfilling the MSW, the amended law on maintenance of cleanliness and order in municipalities was announced on 25th July 2011. The main objectives of the amendment were: an improvement of the WM system, a selective collection of MSW and a reduction of the amount of MSW being landfilled. The next step was to pass a new waste law based on the EU directives in 2012. The WM policies and environmental sustainability have become interlinked elements. The principles and mechanisms that frame waste regulations are key to a successful protection of ecosystems [Tencati et al., 2016].

The rules of municipal waste management

A lot of attention has been paid to waste reduction and recycling within the EU. A large number of regulations and directives focusing on those issues have been created. According to the idea that efficient WM strategies can prevent or reduce the adverse effects on the environment and human health, the EU created the concept of the "waste hierarchy" (Figure 1), which sets a specific priority order of designing the waste legislation [Andreoni et al., 2015]. In order to reach the sustainability in waste managing (i.e. treatment of waste in a proper way and production of secondary raw materials and energy resources) the following waste hierarchy should be applied according to the directive [Knauf, 2015; Pomberger et. al., 2017]:

The current waste law of 14th December 2012 is the basic act that regulates the WMS. The law generally defines the rules to be followed when dealing with waste. The announcement of the Act of 1st July 2011 amending the Law on cleanliness and order in municipalities and certain other acts has become a very important step for the Polish legislation aimed at unifying the functioning of the MWMS. The law regulates the rules related to ensuring the maintenance of order and cleanliness in municipalities. Moreover, it discusses the responsibilities of municipalities in the field of providing the conditions for recycling, recovery or selective waste collection. The introduced system allows to impose the responsibility for proper WM and disposal on local governments. The changes introduced by the law concern the MWMS, a radical change of which involves the WM responsibilities being taking over by property

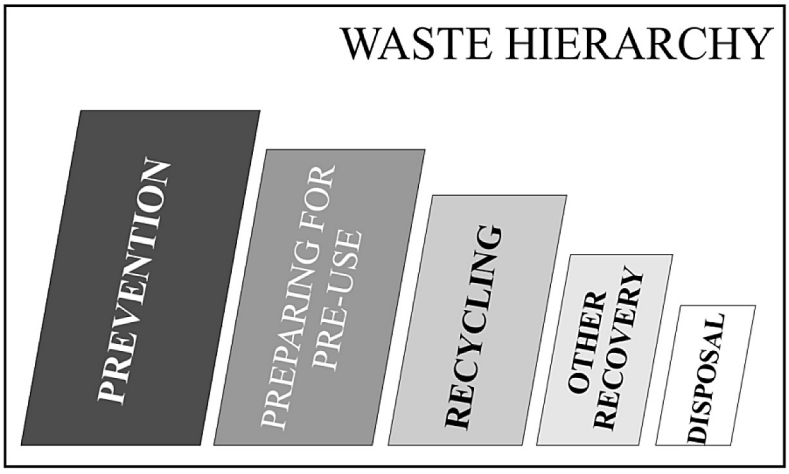

Figure 1. The concept of the waste hierarchy

owners. When the waste hierarchy is applied, the Member States should encourage the actions that deliver the best overall environmental outcome and take the principles of environmental protection as well as technical feasibility and economic viability into account. Article 11 of the Directive describes the measures and goals of re-using and recycling of the waste. Therefore, a separate collection of at least paper, plastic, metal and glass from households and possibly other places (as far as the waste is similar to waste from households) was to set up by 2015, considering the technical, environmental and economic aspects. Finally, by 2020, the preparation for re-use and recycling of the waste fractions mentioned earlier should be increased to a minimum of overall 50% by weight ratio [Pomberger et. al., 2017]. Another way of ensuring a proper functioning of the MWMS is following the so-called 'law of proximity'. According to the hierarchy of conduct, waste should be processed at the place of production or as close to it as possible. This principle significantly reduces the transport costs as well as the risk of harmful effects of waste on the environment, e.g. in the case of transport of hazardous waste.

Selective collection of waste in Poland

One of the first steps in the WM and disposal system involves gathering and collection of waste "at the source", individually in all properties. This is the initial stage of waste segregation, which can be attributed to the degree of ecological knowledge among the people. The solutions used in the waste collection system are divided according to ways of collecting waste. Waste collection means gathering them from the source of their production, that is, from the points and machines through which the waste was put into the system. An important aspect includes the selection of appropriate collection methods (techniques and technologies) related to the frequency of waste reception and the rate of charges. The segregation and collection of waste in the new system is carried out by residents. An important element of the WMS is the Selective Waste Collection Point (SWCP). At a specific place in the municipality, residents have the opportunity to leave certain types of waste. This is the point where the waste that cannot be mixed with other types of waste or collected selectively is gathered. The concept of selective waste collection is derived from the most important assumptions of the common policy, namely, the prevention of MW being deposited in landfills. Currently, Directive 2008/98/EC establishes, as a goal for 2020, that waste reuse and recycling reach 50% of the total waste produced. In the Polish law, the definition of selective collection does not appear until 2008 in the Waste Act of that time. This definition was adopted from Directive 2008/98/EC of the European Parliament and of the Council of 19th November 2008 on waste and repealing certain directives. The term "selective collection" corresponds to the type of collection is during which the type of waste with same characteristics is being gathered in order to make the process of recycling this type of waste easier. This definition, with minor changes, is still valid. Selective collection is one of the main ways of reducing the landfilled waste, because selectively collected waste can be recycled much easier than the recyclable waste selected from mixed MW.

The rules of selective collection of waste in Poland

The methods developed by the EU usually follow a step-by-step plan. The phase of Member States implementing the plan is just starting to assume its practical form. The change of the WMS introduced in Poland has become a very good example of this. On January 1st, 2012 the amendment of the Law on cleanliness and order in municipalities entered into force, and a year later, on July 1st 2013, the MWMS was introduced in all municipalities. The MWMS, due to the amendment of the law on maintenance of cleanliness and order in the municipality, caused significant changes when compared to the situation before introducing the new law. The main aim of the change was to increase the level of recovery and recycling of selectively collected waste and to reduce the amount of biodegradable waste (BW) that is directed to landfills. The key change in the system is the fact that local authorities should be responsible for the collection and management of the waste.. Currently in Poland, the MWMS consists of two basic branches: collection and export as well as waste processing responsible for storing and processing the waste. Since the Law on the maintenance of cleanliness and order in municipalities establishes selective waste collection as the municipality's own task, provided that selective collection includes at least a fraction of paper, metal, plastics, glass and multimaterial and BW, the ways of selective collection are determined

by an act created by the local authorities called 'The rules of the maintenance of cleanliness and order in municipalities'. Therefore, despite the same guidelines for cleanliness and order in the municipalities about which waste fraction is to be selectively collected, there are considerable differences in the way the selective collection of MSW is conducted in different municipalities. This situation occurs because there is no document at a national level that would present the guidelines on how to effectively create a selective waste collection system.

Regional waste management – case study

The selected municipality is located in the south-eastern part of Poland (Figure 2). The population of the municipality is 13,675 inhabitants, accounting for about 12% of the county's population, 51.3% of which are women and 48.7% are men. The average age of the inhabitants is 39.7 years. The average population density in the municipality is 266 people per 1 km^2. The economic situation of the municipality is based mainly on the agriculture and private enterprises operating in the field of economic activity. A significant part of the inhabitants of the municipality works in nearby towns.

The origin of MSW in the municipality mainly involves households and non-residential real estates, which consist of infrastructure objects and utilities. The waste generated in open areas like public green areas or public waste baskets should also be taken into account. The MSW in the selected municipality is collected by means of selective and mixed collection. On the basis of the Waste Management Plan, the area of the voivodship was divided into six WM regions, including: Central, South-East, South-West, Northern, Eastern and Western region. The amount of MSW produced in the area in the years 2013–2015 is presented in Table 1.

In 2013, the total amount of MSW collected in the selected municipality amounted to 1363 Mg, 1019 Mg (75%) of which consisted of produced mixed waste (unsorted). In 2014, it was 1549.2 Mg, 55% (857.4 Mg) of which was MSW. The amount of MSW collected in the selected municipality in 2015 is 1872.74 Mg, including 893.3 Mg (48%) of unsorted waste. The total mass of BW collected in 2013 accounted for 76.3 Mg, 146.9 Mg in 2014, and 1265 Mg in 2015. In 2013 and 2014, among the BW fractions, most frequently collected were paper and cardboard packaging's (2013 – 57%, 2014 – 64%), which have been completely recycled. On the other hand, in 2015 it was noted that the highest percentage of collected BW was code 20 01 08 waste – kitchen waste, which have been composted.

Municipal waste management system in the municipality

The selected municipality gathers waste through a bag-and-container system. Residents are responsible for the purchase of bags for waste collection. The frequency of waste collection depends on their kind. The waste that is generated in the greatest amounts is collected most often. Moreover, the waste that is not collected in bags

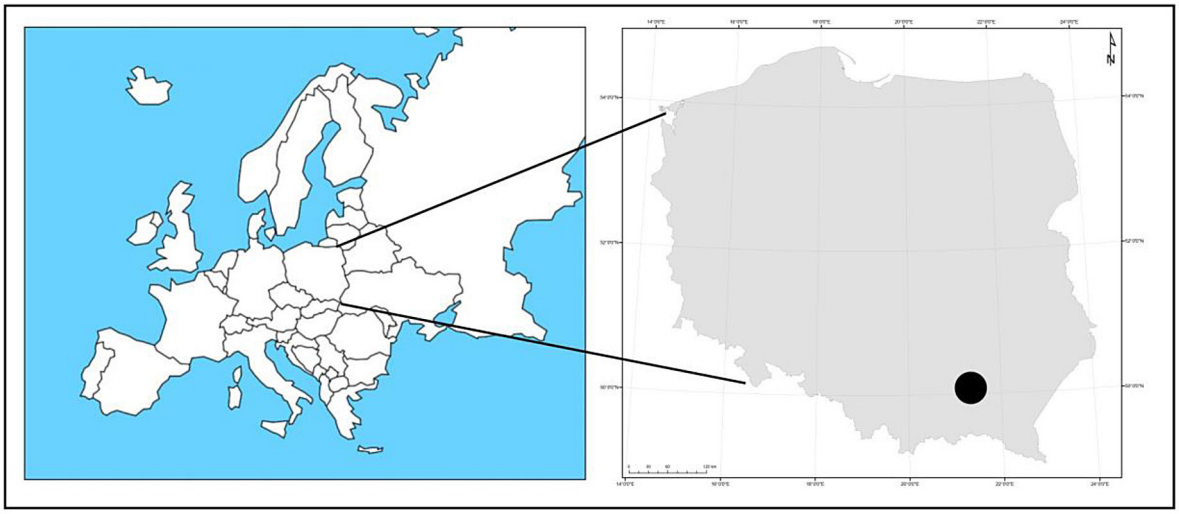

Figure 2. Selected municipality location

Table 1. The amount of municipal waste divided into fractions collected in 2013–2015

Code of collected municipal waste	Type of collected municipal waste	Weight of collected municipal waste in 2013 [Mg]	Weight of collected municipal waste in 2014 [Mg]	Weight of collected municipal waste in 2015 [Mg]
20 02 03	Other non-biodegradable waste	42.0	53.3	52.4
20 01 99	Other, not mentioned, selectively collected fractions – ashes	15.0	80.6	152.4
10 01 01	Slags, furnace ash and dust from boilers (excluding dust from boilers listed in 10 01 04)	-	30.6	-
20 03 01	Non sorted (mixed) municipal waste	1019.0	857.4	893.3
20 03 07	Bulky waste	27.4	64.8	97.1
20 01 35*	Used electronic and electric devices, other that mentioned in 20 01 21 and 20 01 23 containing hazardous ingredients	1.4	9.8	0.5
20 01 36	Used electronic and electric devices, other that mentioned in 20 01 21, 20 01 23 and 20 01 35	4.0	3.9	6.0
20 01 23	Devices containing freons	-	1.3	-
20 01 32	Medicines other than in 20 01 31	-	0.1	-
16 01 03	Used tires	3.0	25.3	8.6
20 01 39	Plastics	1.2	0.4	13.8
15 01 02	Plastic packaging	107.7	84.3	0.9
15 01 04	Metal packaging	0.1	0.2	-
15 01 05	Multimaterial packaging	-	0.2	-
15 01 07	Glass packaging	142.1	180.3	219.7
15 01 06	Mixed packaging	0.1	155.4	241.8
15 01 10*	Packaging containing hazardous substances or being netralized with them	-	1.3	-
17 01 01	Concrete rubble and demolition waste	-	30.02	59.5
17 01 07	Mixed concrete rubble, crushed brick, ceramic materials other than in 17 01 06	-	6.2	-
17 06 04	Isolating materials other than in 17 06 01 and 17 06 03	-	0.3	-
Non landfilled biodegradable waste				
Code of non-landfilled biodegradable waste	Type of non-landfilled biodegradable waste	Weight of non-landfilled biodegradable waste in 2013 [Mg]	Weight of non-landfilled biodegradable waste in 2014 [Mg]	Weight of non-landfilled biodegradable waste in 2015 [Mg]
15 01 01	Paper and cardboard packaging	-	63.8	11.2
20 01 08	Biodegradable waste, kitchen waste	19.1	40.3	73.1
20 02 01	Biodegradable waste	13.4	42.8	42.2

Source based on: Analysis of the MWMS in the selected municipality in 2013, 2014, 2015.

and containers, such as: bulky waste, spent tires, electrical and electronic waste, accumulators and chemicals are collected according to an existing schedule, directly from residents (at least once a year). The waste can also be taken to Selective Waste Collection Point (SWCP). Construction and demolition waste is collected in sturdy bags or dedicated containers provided by the waste collecting company. They are collected once a month or, as in the case of bulky waste, they can be deposited at the SWCP. Overdue medicines and small batteries can be deposited at the collection points located in the Municipality Office, schools, municipal health centres and SWCP.

DISCUSSION

The WM is defined as the activities of "collection, transport, processing, recycling, disposal and monitoring" of the waste in a way that minimizes the damage to the Earth [Demirbas, 2011]. These activities are known to differ according to the location, demographics and nation. Even within the same country, big cities, small cities, suburbs and villages are known to differ in respect to the WM actions [Kayakutlu et al., 2017]. Recent studies conducted an assessment of regional WMS in different parts of the world. Herva et al. [2014] and Niza et al. [2014] studied the system in Porto, Portugal, Zanghelini et al. [2014] and Passarini et al. [2014] in Brazil, Zaman [2014] in Australia, Zamorano et al. [2011] in Spain and Geng et al. [2010] in Japan. All the studies demonstrated the impact of multiple perspectives and factors, which need to be considered in making any decision related to WMS [Kayakutlu et al., 2017]. Many scientists dealt with these issues at a local, regional or national level. Trends and patterns, dynamics and challenges of solid waste generation, reducing, reusing, recycling practices, as well as policies and strategies regarding WM have been recently reviewed for such countries as: India [Gupta et al., 2013], Kuwait [Al-Jarallah and Aleisa, 2014], in the following regions: East Macedonia and Thrace (Greece) [Minoglou and Komilis, 2013], Lombardia and Cantabria (Italy) [Rigamonti et al., 2016], in the following cities: Dar es Salaam, Tanzania [Kirama and Mayo, 2016]; Beijing, China [Yang et al., 2015]; Adelaide, Australia [Song et al., 2015]; New York and San Francisco, USA [Greene and Tonjes, 2014]; Porto, Portugal [Herva et al., 2014]; Barcelona, Spain [Fragkou et al., 2010]; Nis, Serbia [Milutinovic et al., 2014]; Iasi, Romania [Căilean and Teodosiu 2016].

In Poland, according to the current legal directives regarding the MWM, participation in an organised WMS has become a priority for all the country's residents. This article analyses the functioning of the WMS in the area of the selected municipality. The analysis showed that the system works correctly. The new WMS in the municipality was introduced in accordance with Polish law. The municipality fulfilled its statutory obligations and adjusted its municipal WM activities. The conducted analysis allowed to draw the following conclusions: (i) introducing the legal changes in the WMS brought the expected result – a new WMS in the selected municipality, (ii) the WMS in the selected municipality functions correctly, (iii) the most important issue among the municipality residents is the lack of knowledge and social awareness concerning efficient WM. The reason of this may be that the municipality authorities do not sufficiently educate nor inform the residents in this regard, (iv) among the municipality's residents there are still people who do not collect the waste separately. There is no tendency to do so, (v) despite the satisfactory level of the collected waste in the municipality, illegal landfills can still be found there, (vi) the municipality's authorities should focus on educating the residents by presenting the benefits of the correctly conducted waste collection.

CONCLUSION

By adopting a MWMS, the selected municipality made all its residents responsible for their waste. However, the fact of introducing changes alone does not solve the waste problem. Residents are still unaware of the importance of proper waste collection. They cannot indicate which installations are receiving their waste nor do they use additional facilities located throughout the municipality. Littering still occurs there. The most important task for the selected municipality should be performing tasks related to the maintenance of cleanliness in public places and those with a recreational value. The authorities should emphasize the education of the inhabitants in the field of ecology and the environment, through participation in the educational and ecological programs. Another action should be to carry out education and information campaigns on segregation and the principles governing MWMS. Waste hazards create a very important environmental problem. A positive development is the increase of interest in the field of the WM in Poland. Poland, as a member of the EU, should strive for continuous MWMS transformations. This should be not only a duty, but also an act of care of the country's cleanliness and security with regard to the environment and the health and well-being of its people. The findings of this study are a good starting point for further studies that will determine whether the newly introduced system of WM and consequential trends prove to be effective in the long-term perspective. Further studies in this respect are planned for a few years after introducing the new system in hopes of determining whether the system has lived up to its promise.

Acknowledgements

This study was supported by the IGA – Internal Grant Agency Faculty of AgriSciences MENDELU No. TP 5/2017.

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